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NATIONAL DAM SAFETY PROGRAM. J. BRISTOW LAKE DAM (MO 30985), MI--ETC(U)
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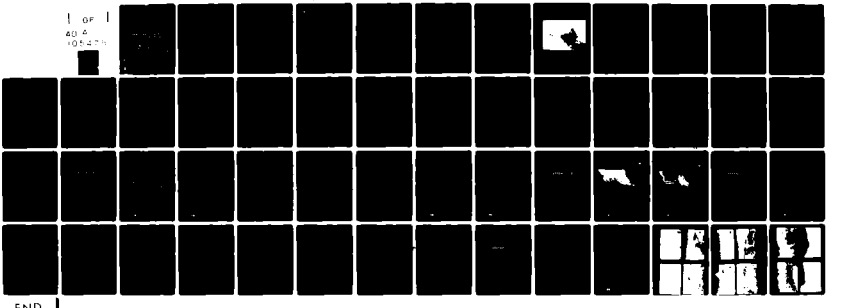

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MISSISSIPPI-KASKASKIA-ST. LOUIS RIVER BASIN

BRISTOW LAKE DAM

CRAWFORD COUNTY, MISSOURI

MO 30985

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST, 1980

UNCLASSIFIED

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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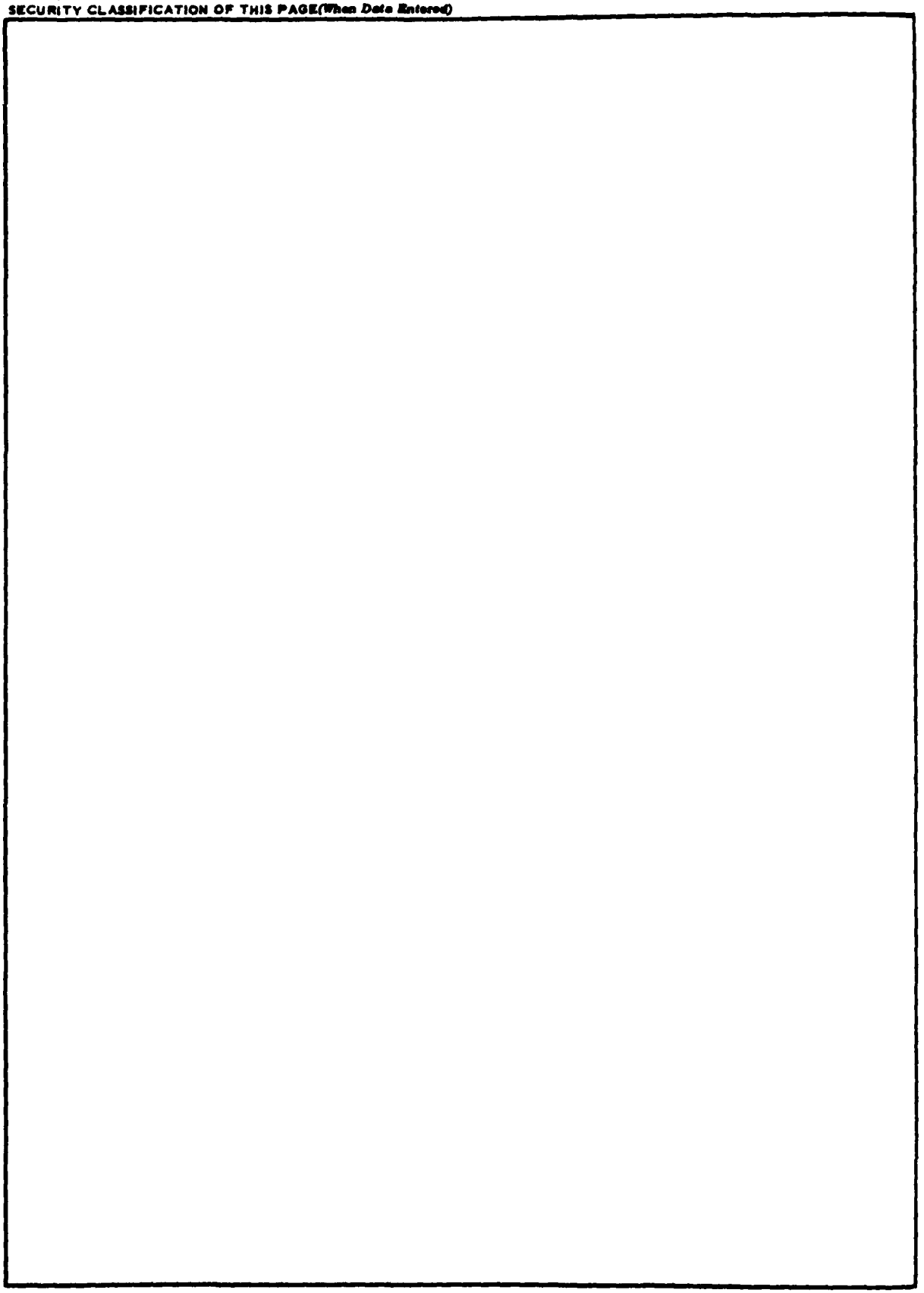


DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: J. Bristow Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the J. Bristow Lake Dam (MO 30985).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 8 SEP 1980 (Date)

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 8 SEP 1980 (Date)

MISSISSIPPI-KASKASKIA-ST. LOUIS RIVER BASIN

J. BRISTOW LAKE DAM

CRAWFORD COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30985

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

August 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam:	J. Bristow Lake Dam
State Located:	Missouri
County Located:	Crawford
Stream:	Tributary of the Meramec River
Date of Inspection:	21 May 1980

J. Bristow Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri, and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately 1 mile downstream of the dam. Located within this zone are a pond at 0.1 miles, a trailer and a dwelling at 0.2 miles, and a dwelling at 1.0 miles. The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken. The dam is in the small size classification, since it is greater than 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 acre-ft but less than 1,000 acre-ft.

Our inspection and evaluation indicate that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass 15 percent of the Probable Maximum Flood (PMF) without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering this dam's small size and low storage capacity, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 1 percent probability flood will not overtop the dam. The 1 percent

probability flood is one that has a 1 percent chance of being exceeded in any given year.

Deficiencies visually observed by the inspection team were: (1) tree and brush growth on both the upstream and downstream face; (2) lack of wave protection for the upstream embankment face; (3) lack of a non-erodible spillway control section; (4) some animal burrows on the downstream face; (5) heavy tree and brush growth in the spillway outlet channel; and (6) leakage of an undetermined source from the reservoir. Another deficiency was the lack of seepage and stability analysis records.

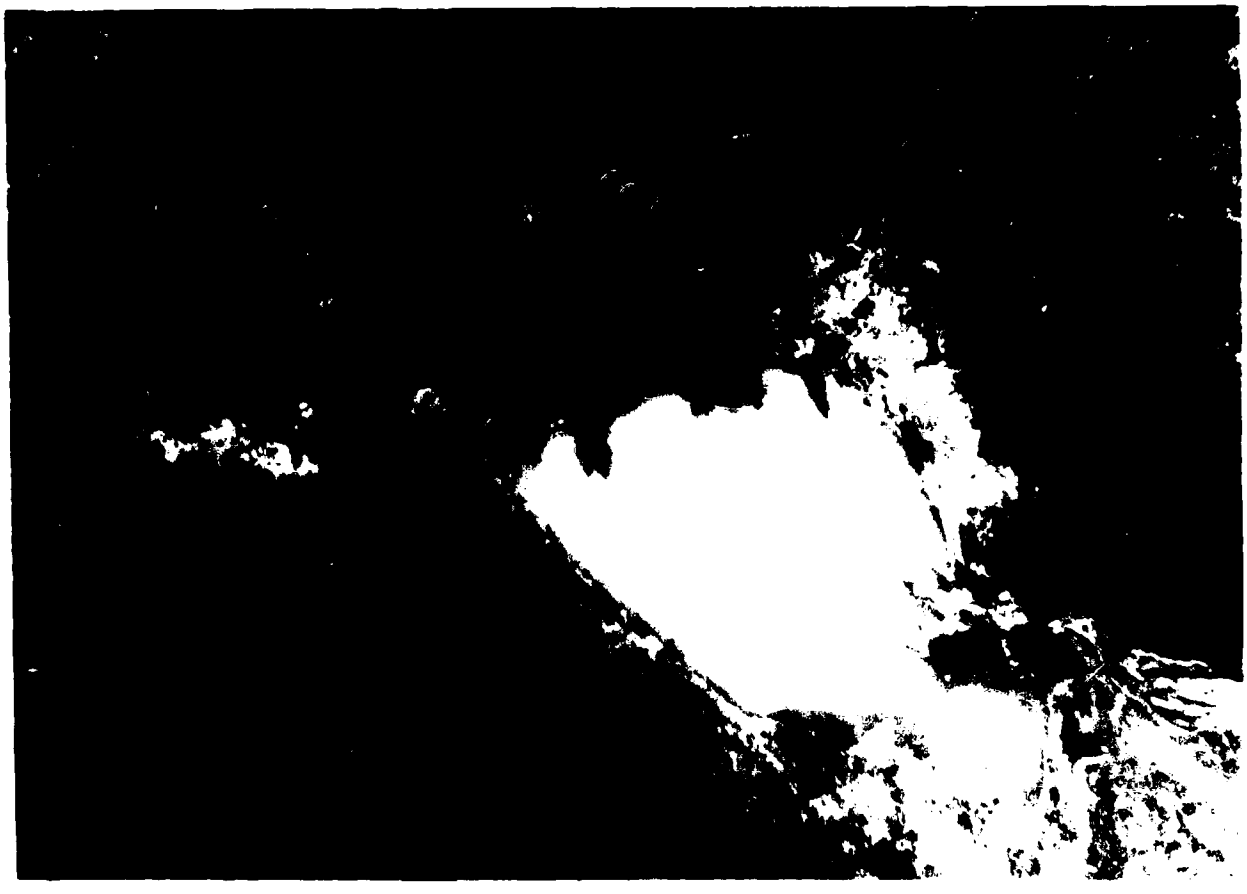
It is recommended that the owners take the necessary action promptly to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Steve Brady, P.E., (AEI)

Tom Beckley, P.E., (AEI)

Gene Wertepny, P.E., (HEI)

Dave Daniels, P.E., (HEI)



AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
J. BRISTOW LAKE DAM - ID No. 30985

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of J. Bristow Lake Dam in Crawford County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

J. Bristow Lake Dam is an earth fill structure approximately 30 ft high and 330 ft long at the crest. The appurtenant works consist of an earth cut swale in the right abutment. There are no other appurtenant structures. Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankment. Presented on Sheet 4 of Appendix A are a profile and section of the spillway.

B. Location:

The dam is located in the west-central part of Crawford County, Missouri, on a tributary of the Meramec River. The dam and lake are within the Indian Springs, Missouri, 7.5 minute quadrangle sheet (Section 32, T38N, R4W - latitude 37° 58.5'; longitude 91° 22.9'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 30 ft and a maximum storage capacity of approximately 131 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately 1 mile downstream of the dam. Located within this zone are a pond at 0.1 miles, a trailer and a dwelling at 0.2 miles, and a dwelling at 1.0 miles. The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken.

E. Ownership:

The dam is owned by Mr. Jesse Bristow. The owner's address is 7336 Maryland, Clayton, Missouri 63105 (Telephone 314-725-9395).

F. Purpose of Dam:

The dam was constructed primarily for fishing and recreation.

G. Design and Construction History:

There are no plans or design calculations available. The only design information is that written in the contract between the owner and the contractor. That information as related over the telephone by the owner indicates that the dam was to be 420 ft long and 29 ft high at its highest point with an upstream slope of 3H:1V and a downstream slope of 2H:1V, and a crest width of 12 ft. The dam was to have a 10 ft wide clay core keyed into "good clay."

The dam was constructed in the fall of 1966 by Halbert Construction Company of Steelville, Missouri. Mr. B. L. Halbert indicated that most of the borrow was obtained from the lake area, with some borrow obtained from the left abutment area above the dam. He indicated that the valley bottom soil profile consisted of about 4 ft of sand and gravel over clay. He said that the dam consisted of mainly sand and gravel fill with a 10 ft wide clay core in the center which extended about 6 ft below the base of the dam into clay. The clay core extends up through the dam to the crest. The fill material was placed and compacted with scrapers. No modifications have been made since the dam was built.

H. Normal Operating Procedures:

The dam has never overtopped. The lake has never filled completely so that water has never gone over the spillway. The owner has indicated that the water level in the lake has never been more than about 10 ft above the lake level on the day of the inspection. The owner believes that water is leaking out the bottom of the basin, but he has never been able to find the exit point downstream of the dam.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the USGS quad sheet, is approximately 211 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through an uncontrolled spillway.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 818.1): 280 cfs

(3) Estimated Capacity of Primary Spillway: 280 cfs

(4) Estimated Experienced Maximum Flood at Dam Site: Spillway has never been used.

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level (MSL) elevation of 817 for the top of a rock ledge located 10 ft left of the centerline at Station 3+65 (estimated from quadrangle map).

(1) Top of Dam: 818.1 (Low Point); 819.7 (High Point)

(2) Principal Spillway Crest: 815.2

(3) Emergency Spillway Crest: None

(4) Principal Outlet Pipe Invert: Not Applicable

(5) Streambed at Centerline of Dam: 789.0

(6) Pool on Date of Inspection: 791.7

(7) Apparent High Water Mark: 802.4

(8) Maximum Tailwater: None

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 1,400 ft

(2) At Principal Spillway Crest: 1,250 ft

(3) At Emergency Spillway Crest: Not Applicable

E. Storage Capacities:

(1) At Principal Spillway Crest: 106 acre-ft

(2) At Top of Dam: 131 acre-ft

(3) At Emergency Spillway Crest: Not Applicable

F. Reservoir Surface Areas:

(1) At Principal Spillway Crest: 7.2 acres

(2) At Top of Dam: 10 acres

(3) At Emergency Spillway Crest: Not Applicable

G. Dam:

(1) Type: Earth (sand and gravel shell with clay core)

(2) Length at Crest: 330 ft

(3) Height: 30 ft

(4) Top Width: 12 ft

(5) Side Slopes: Upstream 2.9:1 (Top), 3.8:1 (Bottom); Downstream 2.1:1 (Top), 3.7:1 (Bottom)

(6) Zoning: Sand and Gravel with Clay Core

(7) Impervious Core: 10 ft wide

(8) Cutoff: 6 ft Below Base of Dam

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: Right Abutment

(2) Type: Earth Cut

I.2 Emergency Spillway:

(1) Location: Not Applicable

(2) Type: Not Applicable

J. Regulating Outlets:

There are no regulating outlets associated with this dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering data exist for this dam. No documentations of construction inspection records were available. There are no documented maintenance data.

A. Surveys:

No information regarding pre-construction surveys was obtained. Sheet 3 of Appendix A presents a plan, profile, and cross section of the dam from survey data obtained during the site inspection. The top of a rock ledge at station 3+65, 10 ft left of centerline, was used as a site datum of assumed elevation 817.

B. Geology and Subsurface Materials:

The site is located in the north-central portion of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus, and deep valleys. The most common bedrock types are dolomite, sandstone, and chert. The "Geologic Map of Missouri" indicates that the bedrock in the site area consists primarily of the Gasconade formation of the Canadian Series in the Ordovician System. The Gasconade formation is predominantly a light brownish-gray, cherty dolomite. In this area, the average thickness of the Gasconade is 200 ft. Caves and springs are common in this formation. The publication "Caves of Missouri" lists a total of seven caves known to exist in Crawford County. Most of these caves are clustered in a three square mile area about 10 miles northeast of the site. The rest are farther northeast.

The "Geologic Map of Missouri" indicates a normal fault passing about three miles west of the site in a northwest-southeast direction. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years (rock associated with the Ordovician Period - 500 million years old).

Soils in the area of the dam site appear to be primarily thin deposits of residual silty clays with rock fragments. The soils are of the Clarksville-Fullerton-Talbott Soil Association and have developed from thin loessial soils deposited over weathered material from cherty dolomites. The loessial thickness map indicates that upland areas may have between 2.5 and 5.0 ft of loess cover.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the guidelines. The builder of the dam indicated that the embankment consists mainly of sand and gravel obtained from the lake area. He also indicated that a central 10 ft wide clay core was incorporated, which extends 6 ft below the base of the dam and keys into a clay material.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. Based on a field check of spillway dimensions and embankment elevations, and a check of the drainage area on USGS quad sheets, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 9.

E. Structure:

There are no structures associated with this dam.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION:

Normal flows would be passed by an uncontrolled earth-cut spillway located in the right abutment. No operating facilities exist.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on May 21, 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri, and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Gene Wertepny - Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam appears to be in good condition. The upstream face had some scattered small trees and brush. The slope is relatively flat (see Sheet 3 of Appendix A), and there was no sloughing or significant erosion. There was no riprap protection (see Photo No. 14).

The horizontal alignment of the crest appeared good, and no surface cracking or unusual movement was obvious. The crest slopes from the left to the right abutment (see profile - Sheet 3 of Appendix A). It is not known whether it was constructed this way, or if some settlement has occurred (see Photo No. 3).

The downstream face was thinly to moderately covered with trees and brush with some animal burrows noted. No sloughing or serious erosion was evident on the embankment or at the embankment-abutment contacts. The valley and the original streambed were investigated for a distance of about 200 ft downstream of the dam for signs of seepage, but none was found (see Photos 5 and 6). Sheet 5 of Appendix A presents a plan sketch of the dam showing observed features.

Auger probes in the crest of the dam indicated a red-brown cherty silty clay material (ML-CL). Material was more sandy on the downstream slope, with some fairly large rocks evident.

C. Appurtenant Structures:

C.1 Primary Spillway:

The spillway is an earth cut in the right abutment. Some weathered rock ledges (dolomite) were evident near the crest and in the outlet area. The approach area had a few scattered trees, and the outlet channel was fairly densely overgrown with trees and brush. There was a small erosional area in the approach channel caused by surface drainage back down into the lake. There is no permanent control section at the crest of the spillway. The spillway has apparently never been used (see Photos 8, 9, and 10).

C.2 Emergency Spillway:

There is no emergency spillway.

D. Reservoir:

The watershed is densely wooded with moderate slopes. The lake itself was only about an acre in plan area on the day of inspection due to a relatively dry spring, evaporation, and apparent leakage. The lake was only a few feet deep on the day of inspection and has never been more than 10 ft above that level, according to the owner. No evidence of significant sedimentation was observed.

E. Downstream Channel:

The downstream channel is fairly well defined, starting about 50 ft downstream of the downstream toe, and is about 12 to 15 ft wide and about 4 ft deep. The channel is lined with trees and brush and had no water in it for a distance of at least 200 ft downstream of the dam (area inspected) on the day of the inspection.

3.2 EVALUATION:

Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing. There is no wave protection provided for the upstream face of the embankment. A non-erodible control section is not provided for the spillway; therefore, progressive erosion could lower the elevation of the spillway, and thus lower the normal pool elevation of the reservoir. The brush and tree growth in the spillway inlet and outlet channel could restrict flood flows.

The deficiencies are not as critical from an urgency standpoint since this lake has never held water for a sustained period, and the spillway has never been used. However, the correction of these deficiencies represents fairly standard practice for the construction and maintenance of dams. Also, the occurrence of a very large flood could fill up the lake very quickly and substantially increase the risk associated with the deficiencies.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with this dam. The pool is normally controlled by rainfall, runoff, evaporation, the capacity of the uncontrolled spillway, and apparent leakage from the reservoir.

4.2 MAINTENANCE OF DAM:

The presence of tree and brush growth on the embankment indicates that little maintenance is done.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The vegetation on the dam, animal holes, and lack of riprap and a non-erodible spillway control section are deficiencies which could become serious if the lake were to hold water for a sustained period.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The owner has indicated the dam has never overtopped, and that the spillway has never operated. Information from the owner indicates that the highest water level in the lake was at approximate elevation 802.4. Our hydrologic and hydraulic analyses using U.S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

The approach area to the spillway has a few scattered trees, and the outlet area is fairly densely overgrown with trees and brush. There is no non-erodible spillway control section. The spillway outlet channel is well separated from the embankment, and spillway releases would not be expected to endanger the dam.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U.S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the reservoir storage and the pool and drainage areas from the Indian Springs, Missouri, 7.5 Minute USGS quad sheet.

Based on the hydrologic and hydraulic analyses presented in Appendix C, the spillway will pass 15 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the dam's small size and low storage capacity,

50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillway will pass the 1 percent probability flood without overtopping the dam.

Application of the Probable Maximum Precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 4,374 cfs. For 50 percent of the PMP, the peak inflow was 2,187 cfs.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 2.9 ft at elevation 821. The duration of the overtopping will be 6.7 hours, and the maximum outflow will be 3,919 cfs. The maximum discharge capacity of the spillway is 280 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 1.9 ft at elevation 820. The maximum outflow will be 1,855 cfs, and the duration of overtopping will be 4.3 hours. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data for the foundation and embankment were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

There are no operating facilities for this dam.

D. Post-Construction Changes:

There have been no post-construction changes or modifications to this dam.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) tree and brush growth on both the upstream and downstream face; (2) lack of wave protection for the upstream embankment face; (3) lack of a non-erodible spillway control section; (4) some animal burrows on the downstream face; (5) heavy tree and brush growth in the spillway outlet channel; and (6) leakage of an undetermined source from the reservoir. Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 15 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued promptly.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

(2) An investigation should be made as to the nature and source of the apparent leakage from the lake to determine whether this could be detrimental to the safety of the dam in the event of a large flood.

B. O & M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(2) A non-erodible spillway control section should be provided so that progressive erosion of the spillway will not lower the normal pool of the reservoir.

(3) Wave protection should be provided for the upstream face of the dam.

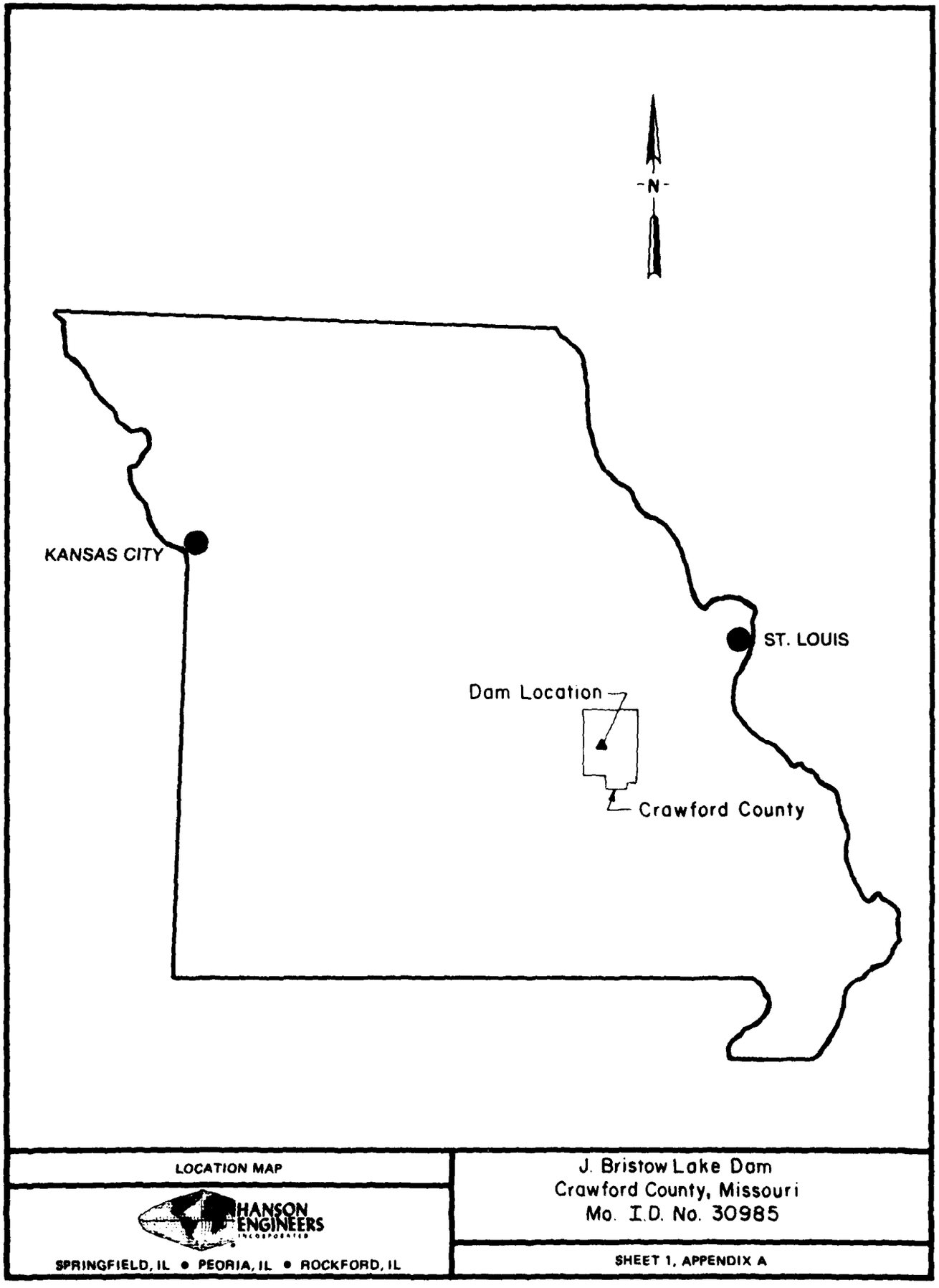
(4) The tree and brush growth on the dam and in the spillway should be cut annually. Initial removal of large trees should be performed under the direction of an engineer experienced in the design and construction of earth dams.

(5) Animal holes should be filled.

(6) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



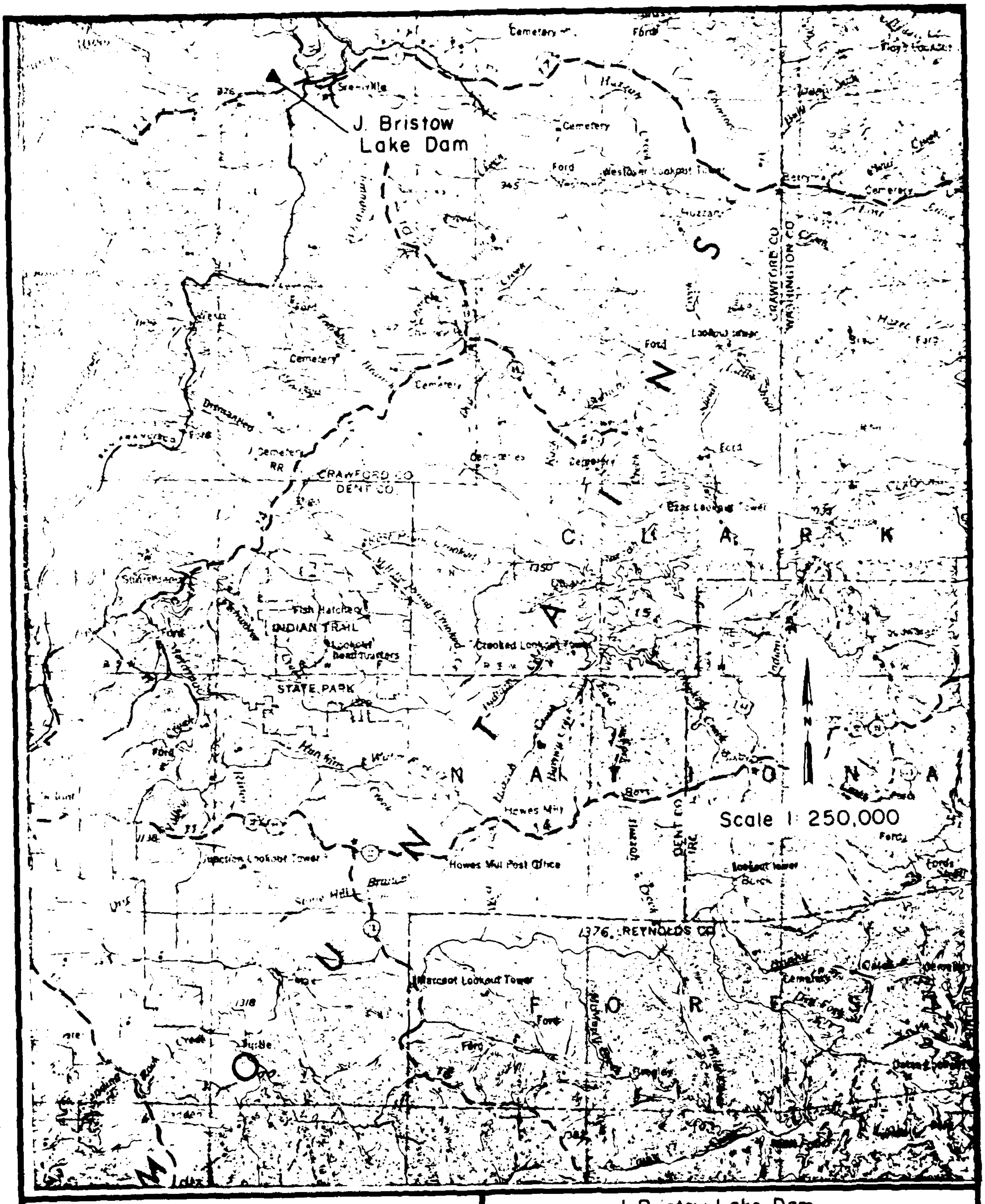
LOCATION MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

J. Bristow Lake Dam
Crawford County, Missouri
Mo. I.D. No. 30985

SHEET 1, APPENDIX A



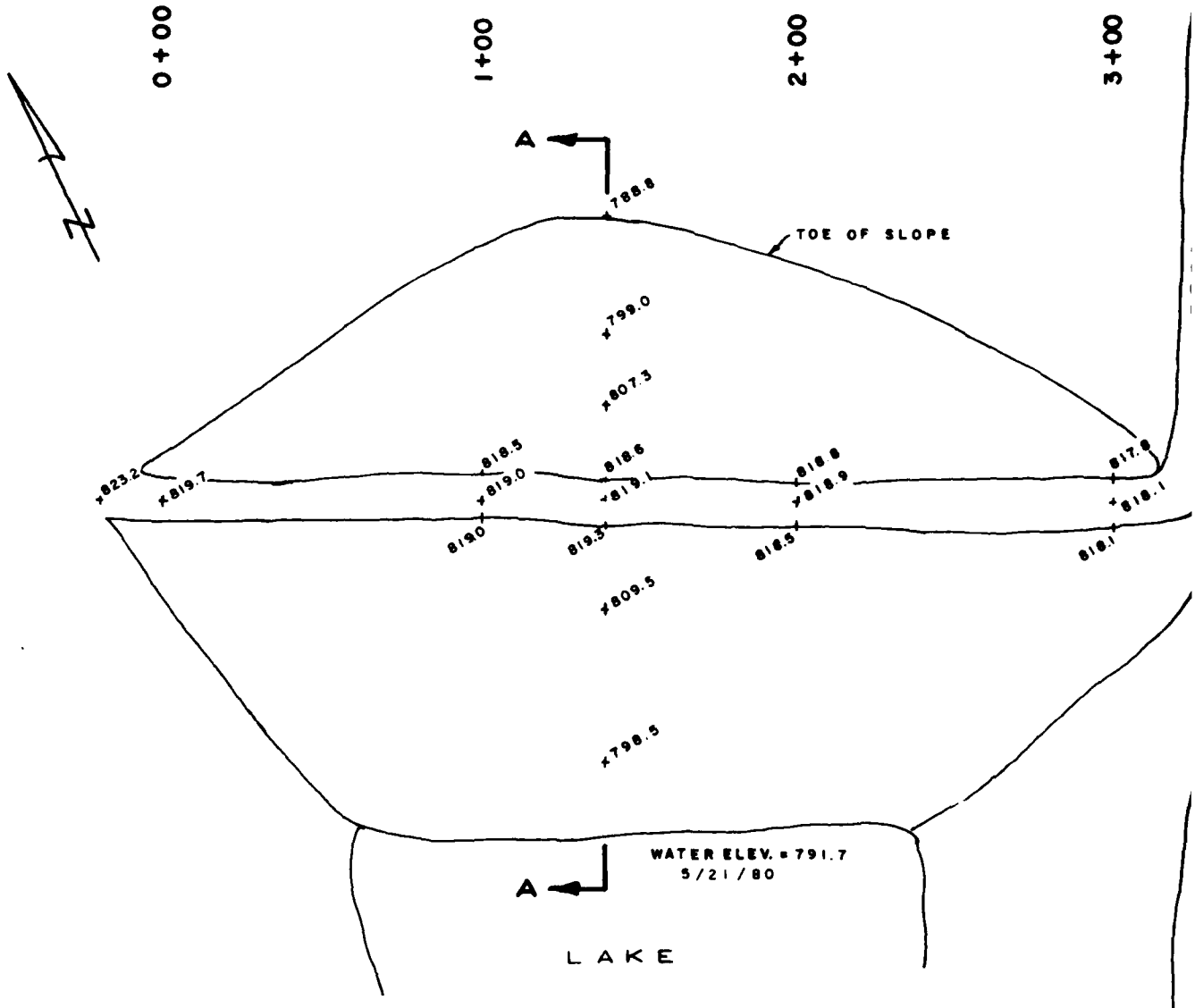
VICINITY MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

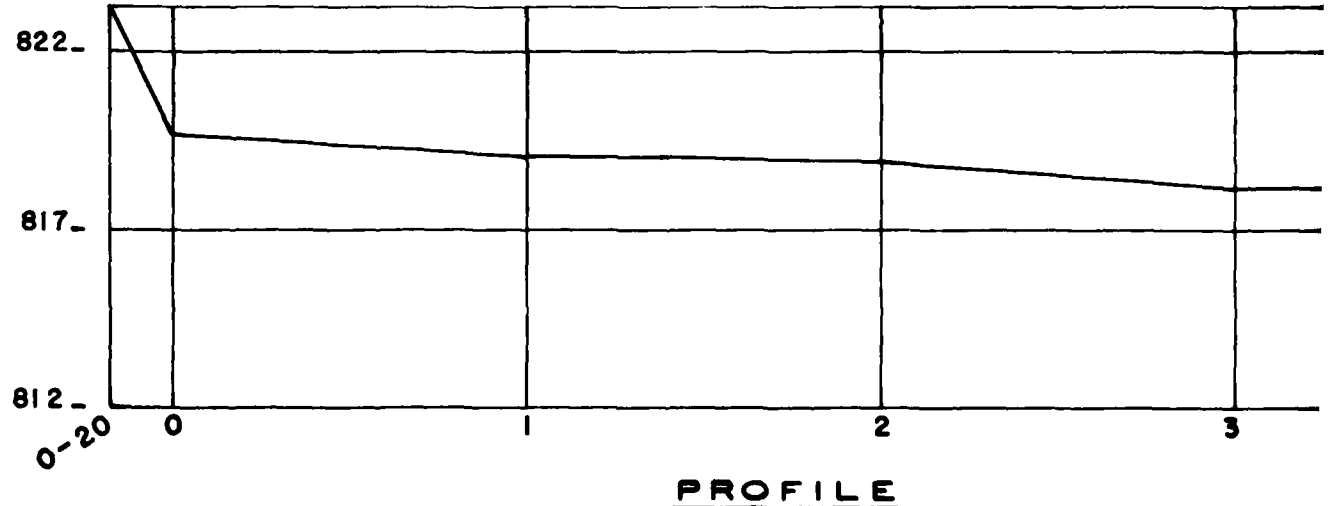
J. Bristow Lake Dam
Crawford County, Missouri
Mo. I.D. No. 30985

Sheet 2, Appendix A

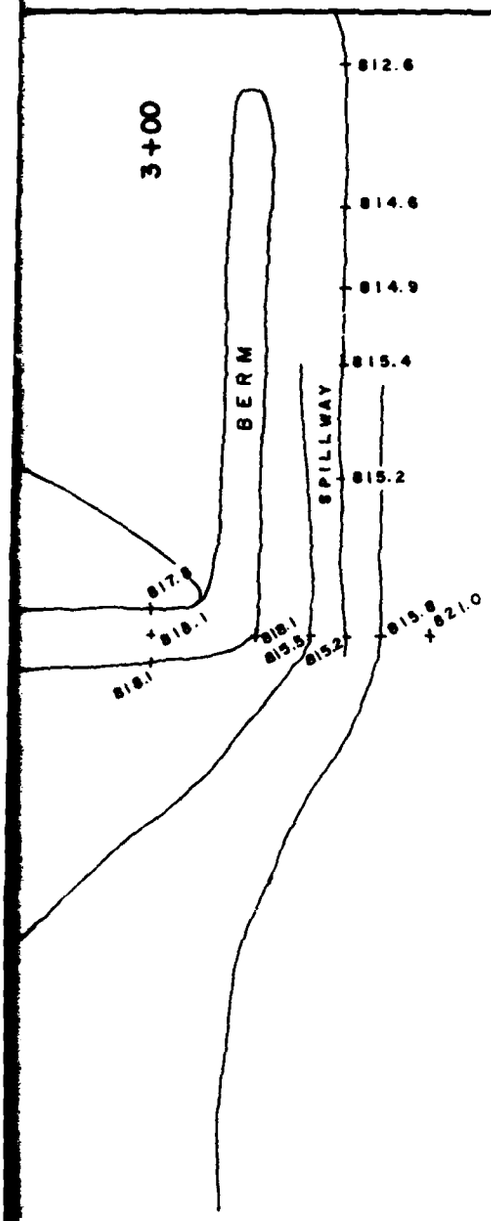


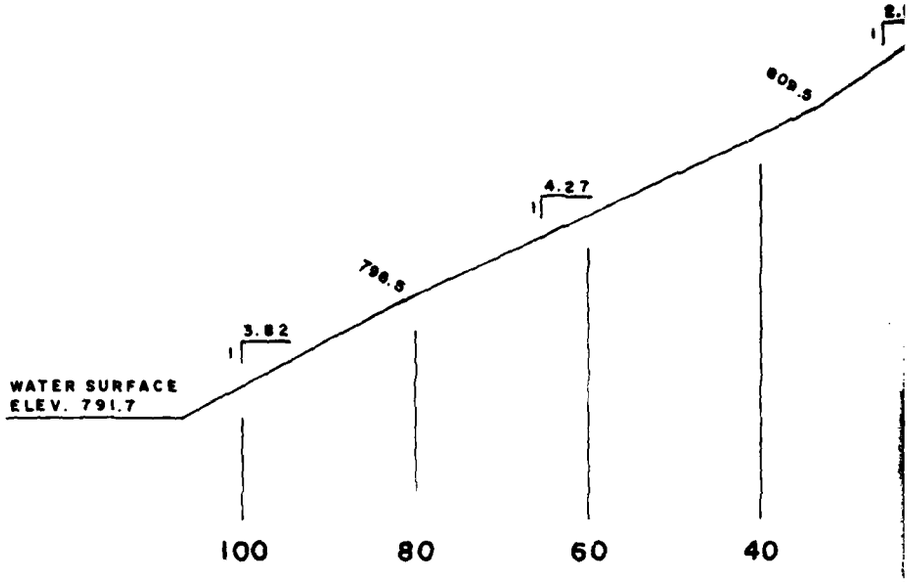
PLAN VIEW

SCALE: 1" = 50'



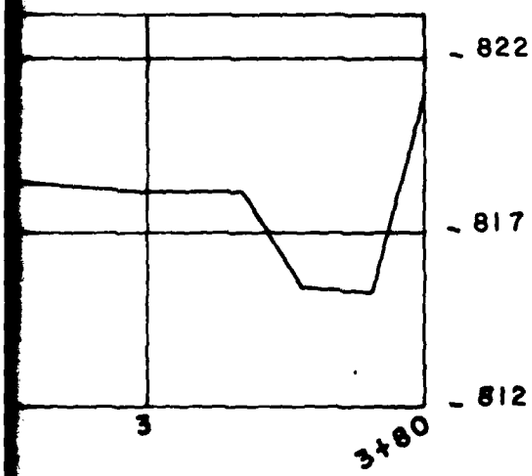
PROFILE

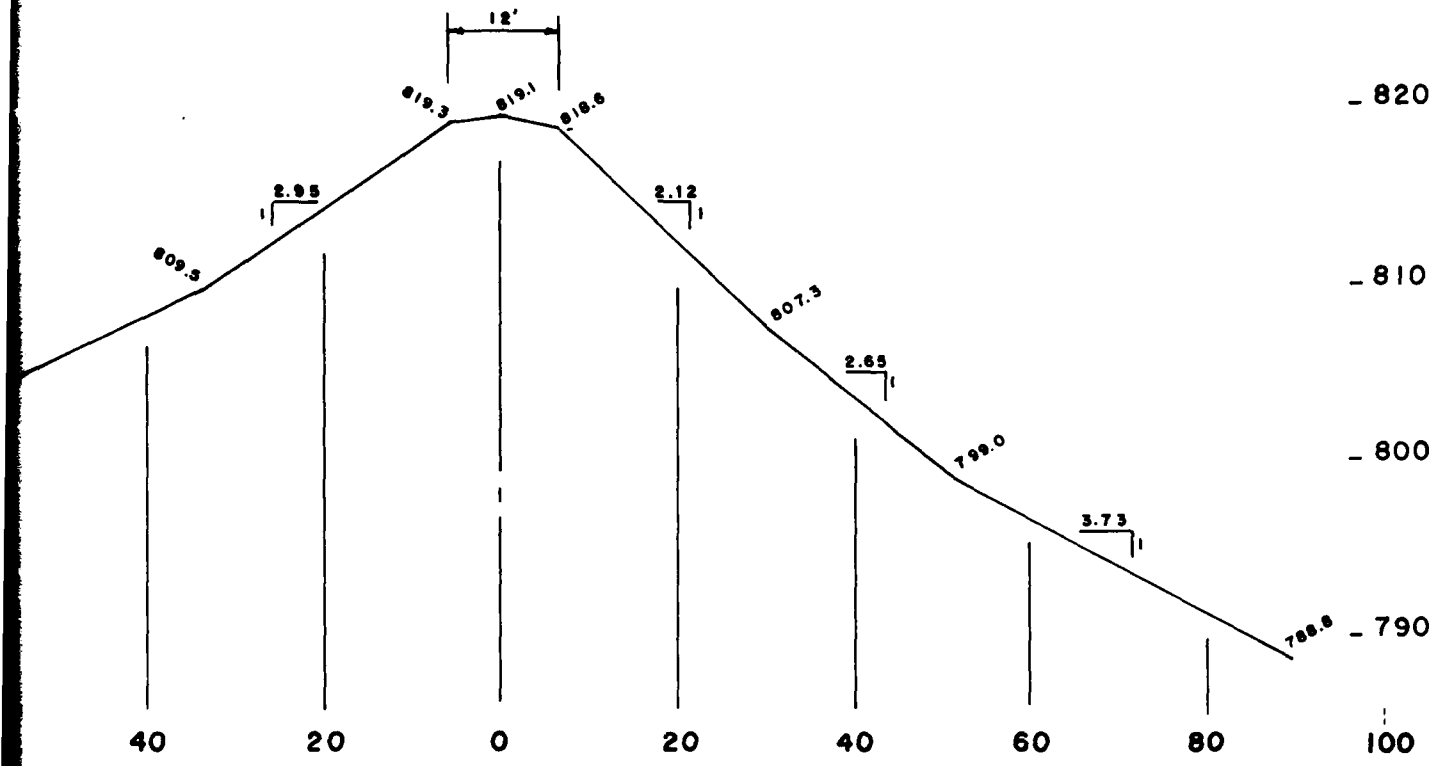




SECTI

BENCHMARK
TOP OF ROCK LEDGE STA 3+65
10' LEFT ℄ ELEV. = 817.00





SECTION A-A STA 1+39

SHEET 3 APPENDIX A

ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

J. BRISTOW LAKE DAM
MO. No. 30985

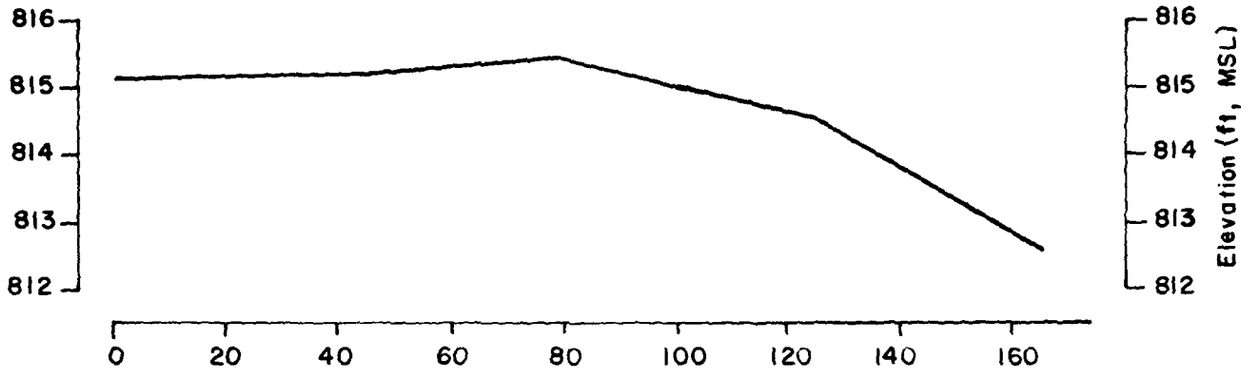
PLAN & PROFILE

CRAWFORD COUNTY, MO.

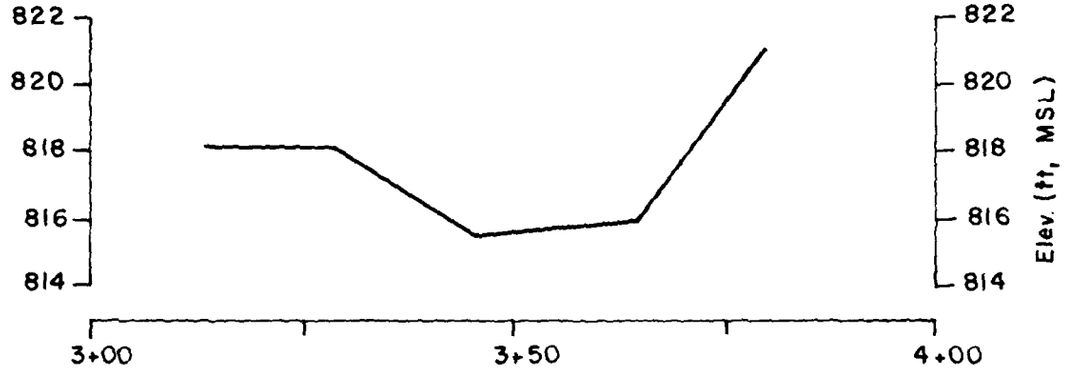
HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Profile and Section of Spillway



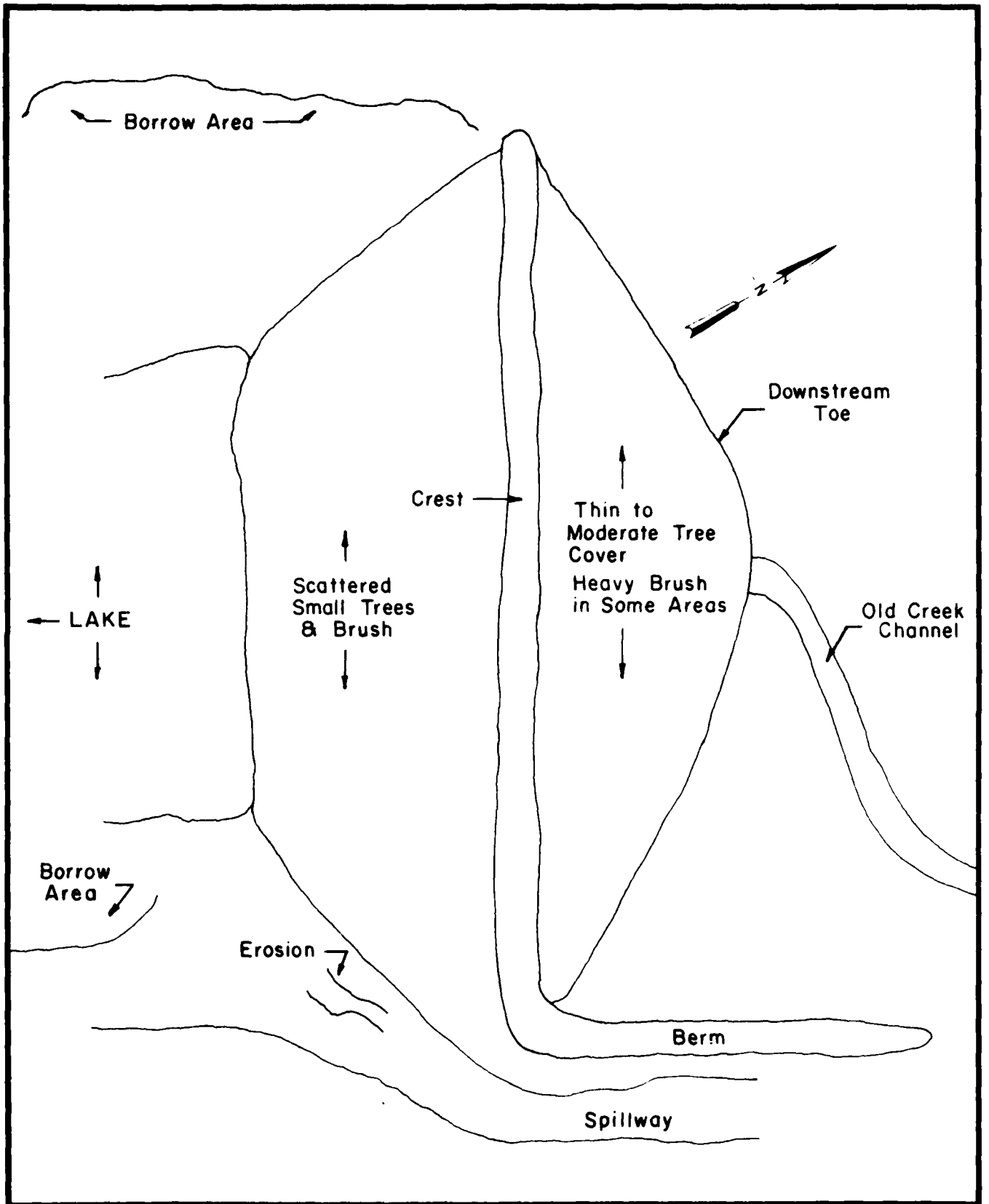
SPILLWAY PROFILE



SPILLWAY CROSS SECTION

J. Bristow Lake Dam
Crawford County, Missouri
Mo. I.D. No. 30985

Sheet 4, Appendix A



PLAN SKETCH OF FEATURES

HANSON ENGINEERS INCORPORATED

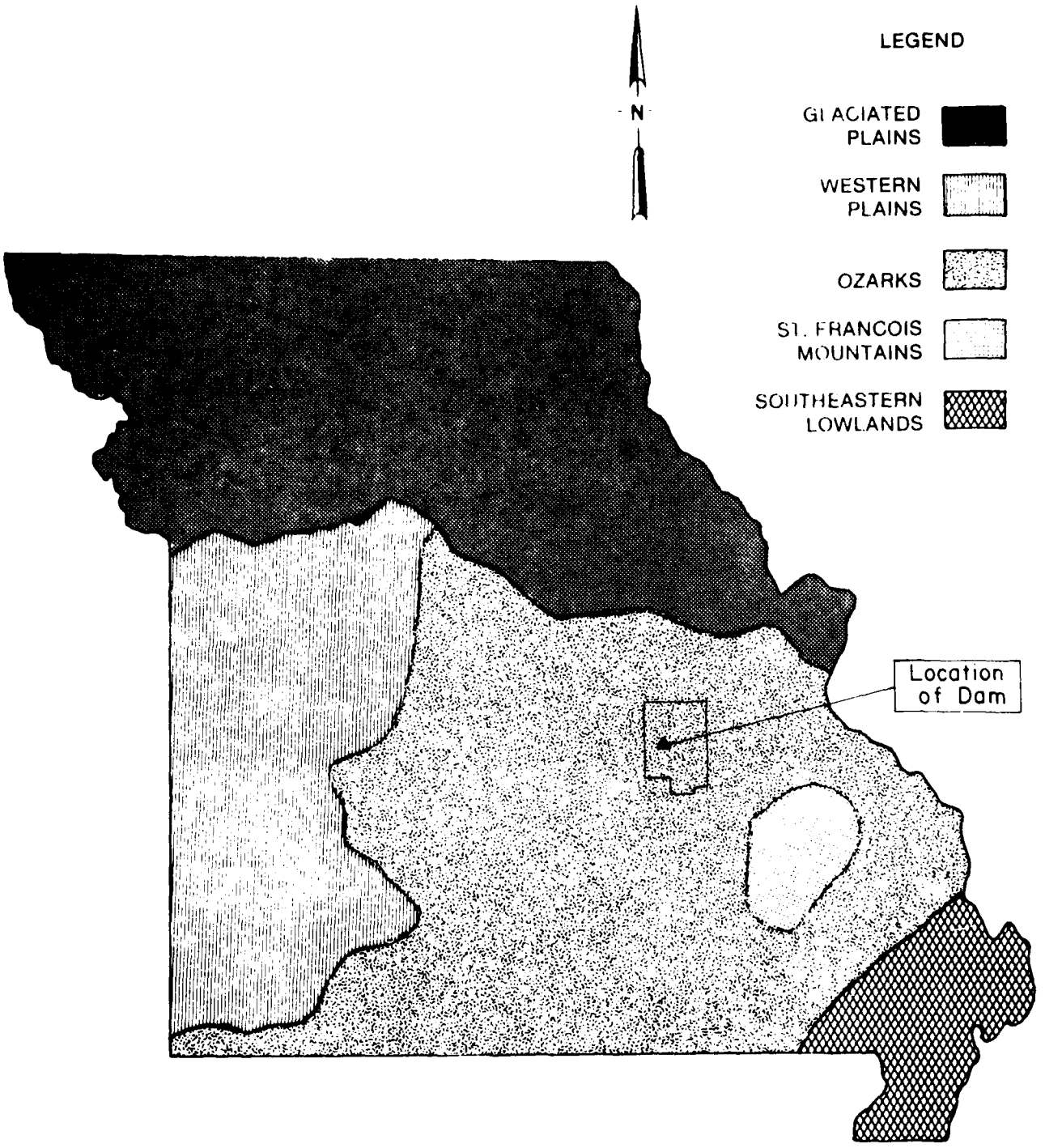
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

J. Bristow Lake Dam
Crawford County, Missouri
Mo. I.D. No. 30985

Sheet 5, Appendix A

APPENDIX B

Geology and Soils



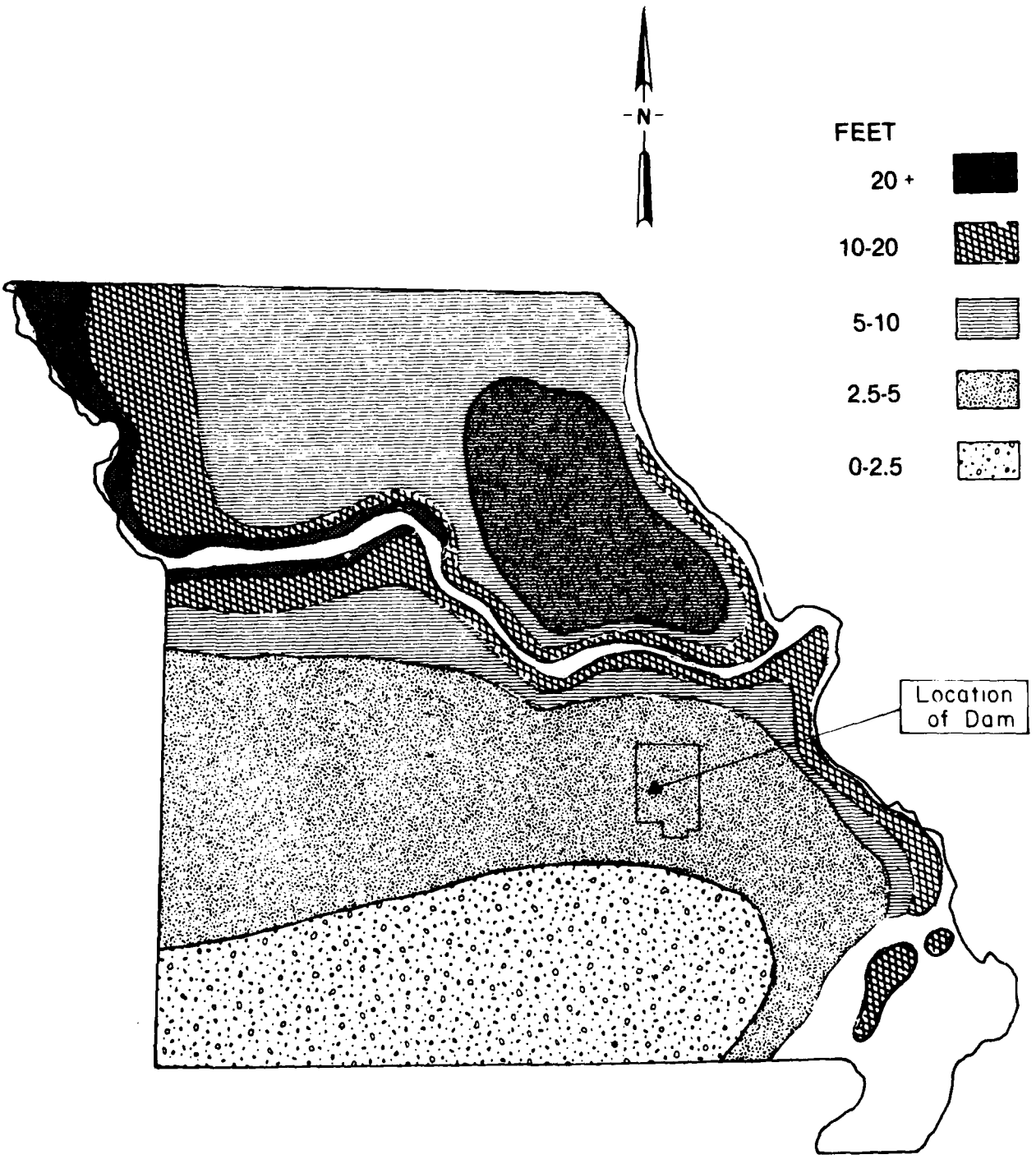
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

J. Bristow Lake Dam
Crawford County, Missouri
Mo I.D. No. 30985

SHEET 1, APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS

HANSON ENGINEERS INCORPORATED

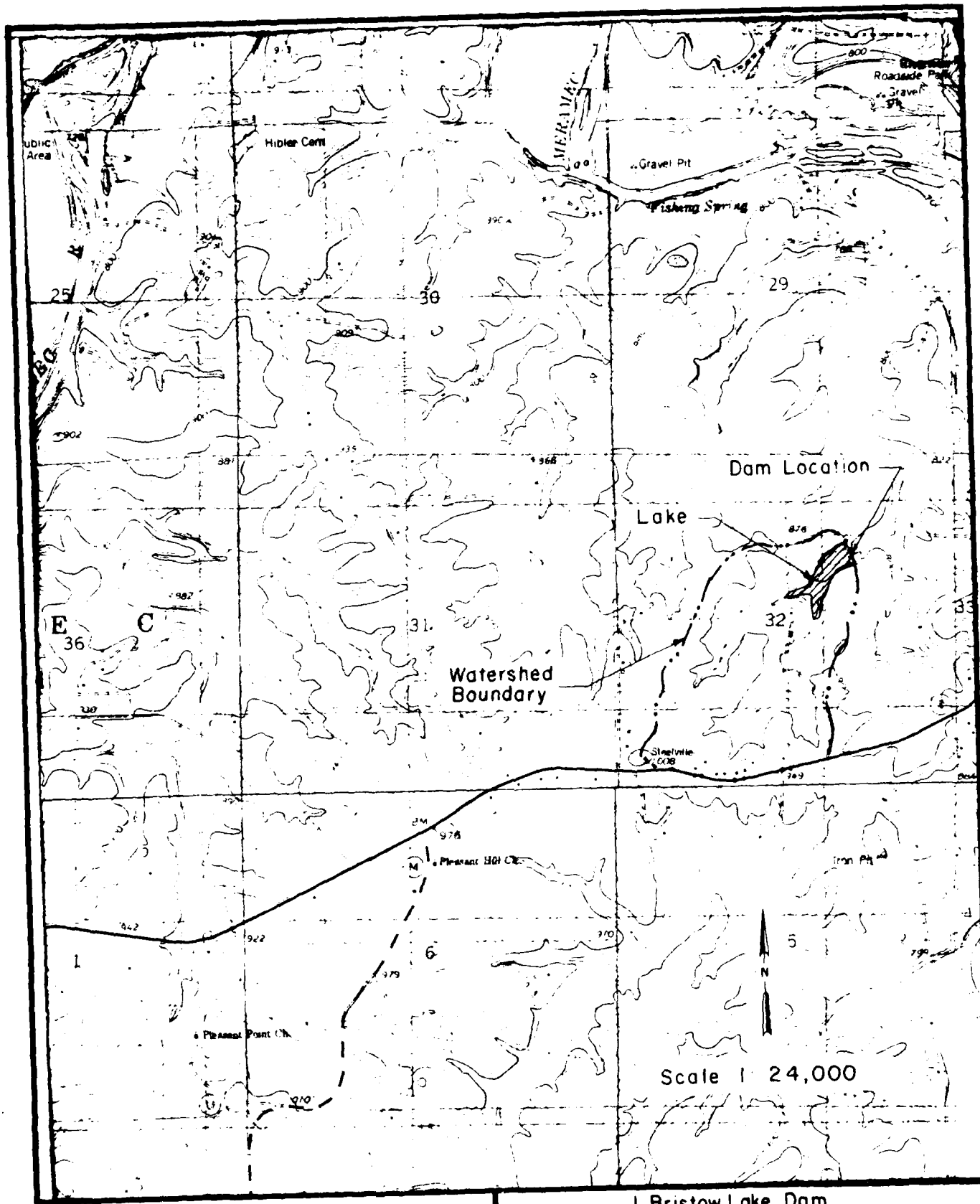
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

J. Bristow Lake Dam
Crawford County, Missouri
Mo. I.D. No. 30985

SHEET 2, APPENDIX B

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

J Bristow Lake Dam
Crawford County, Missouri
Mo. I D. No 30985

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent chance probability flood was routed through the reservoir and spillway. Sullivan rainfall distribution (5 min. interval-24 hours duration), as provided by the St. Louis District, Corps of Engineers, was used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 3, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 4, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 4, Appendix C.) The reservoir level in this dam has been much lower than the spillway crest elevation. To consider the effect of the reservoir storage, an antecedent storm of 25 percent and 50 percent of the PMF was considered assuming the reservoir at elevation 802.4 (mean annual high water) to determine the starting reservoir elevation for the routing of 50 percent and 100 percent of the PMF respectively. Both antecedent storms will fill the reservoir. Thus, the final routing analysis was accomplished starting at the spillway crest elevation (815.2).

The rating curve for the spillway (see Table 4 Sheet 5. Appendix C) was determined assuming critical flow over a broad-crested weir.

The flow over the crest of the dam during overtopping was determined using the non-level dam option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 6, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 7, 8 and 9 of Appendix C.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.33 sq. miles
Length of Watercourse (L)	0.70 miles
Difference in elevation (H)	193 feet
Time of concentration (Tc)	0.23 hours
Lag Time (Lg)	0.14 hours
Time to peak (Tp)	0.18 hours
Peak Discharge (Qp)	887 cfs
Duration (D)	5 min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
5	356
10	874
15	704
20	325
25	158
30	74
35	35
40	17
45	8
50	4
60	0

(*) From the computer output

FORMULA USED:

$$Tc = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A.Q}{Tp} \qquad Q = \text{Excess Runoff} = 1 \text{ inch}$$

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	33.80	30.76	3.04
1% Prob. Flood	24	7.23	2.95	4.28

Additional Data:

1) Soil Conservation Service Soil Group B
2) Soil Conservation Service Runoff Curve CN = 78 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 60 (AMC II) for the 1 percent chance flood
4) Percentage of Drainage Basin Impervious 4 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
789.0	0	0	-
800.0	3.9	21	-
802.4	4.4	34	-
*815.2	7.2	106	0
**818.1	10.0	131	280
820.0	11.9	152	631
825.0	15.0	219	-

*Primary spillway crest elevation
**Top of dam elevation

TABLE 4

SPILLWAY RATING CURVE

Reservoir Elevation (ft, MSL)	Spillway Discharge (cfs)
815.2	0
815.4	2
815.8	16
817.0	127
*818.1	280
819.0	434
820.0	631
821.0	856

*Top of dam elevation

Formula Used: $Q = C_2.b.H_m^{1.5}$

Q = Discharge in cfs

C_2 = Discharge coefficient from Table 8-7 page 8-58 (Handbook of Hydraulics by King-Brater)

b = bottom width of spillway channel

H_m = energy head

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam
-	-	*815.2	106.0	0	-
0.10	437	817.3	124.0	169	-
0.15	656	**818.1	131.0	274	0
0.20	875	818.6	136.0	418	0.5
0.25	1094	819.0	141.0	604	0.9
0.40	1750	819.7	148.0	1348	1.6
0.50	2187	820.0	152.0	1855	1.9
1.00	4374	821.0	165.0	3919	2.9

The percentage of the PMF that will reach the top of the dam is 15 percent.

*Primary spillway crest elevation
**Top of dam elevation

```
A       OVERTOPPING ANALYSIS FOR NONONAME 853 DAM ( N 9 )
A       STATE ID NO. 30985  COUNTY NAME : CRANFORD
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB N 80S3001
B    300                5
B1     5
J      1       7       1
J1   .10     .15     .20     .25     .40     .50     1.0
K      0       1                               3       1
K1       INFLOW HYDROGRAPH COMPUTATION **
N      1       2    0.33               0.33       1                          1
P      0    26.0     102     120     130
T                                                      -1      -78                0.04
M2  0.23    0.14
X      0      -.1       2
K      1       2                               0       4       1
K1       RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                       1       1
Y1     1                                                      106      -1
Y4 815.2   815.4   815.8   817.0   818.1   819.0   820.0   821.0
Y5     0       2      16     127     280     434     631     856
$G     0      21      34     106     131     152     219
$E   789     800   802.4   815.2   818.1     820     825
$S 815.2
$D 818.1
$L    29     125     238     320     325     330     335
$V 818.1   818.9     819   819.7   820.5   821.0   822.0
K     99
```

PMF Ratios
INPUT DATA

Sheet 7, Appendix C

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

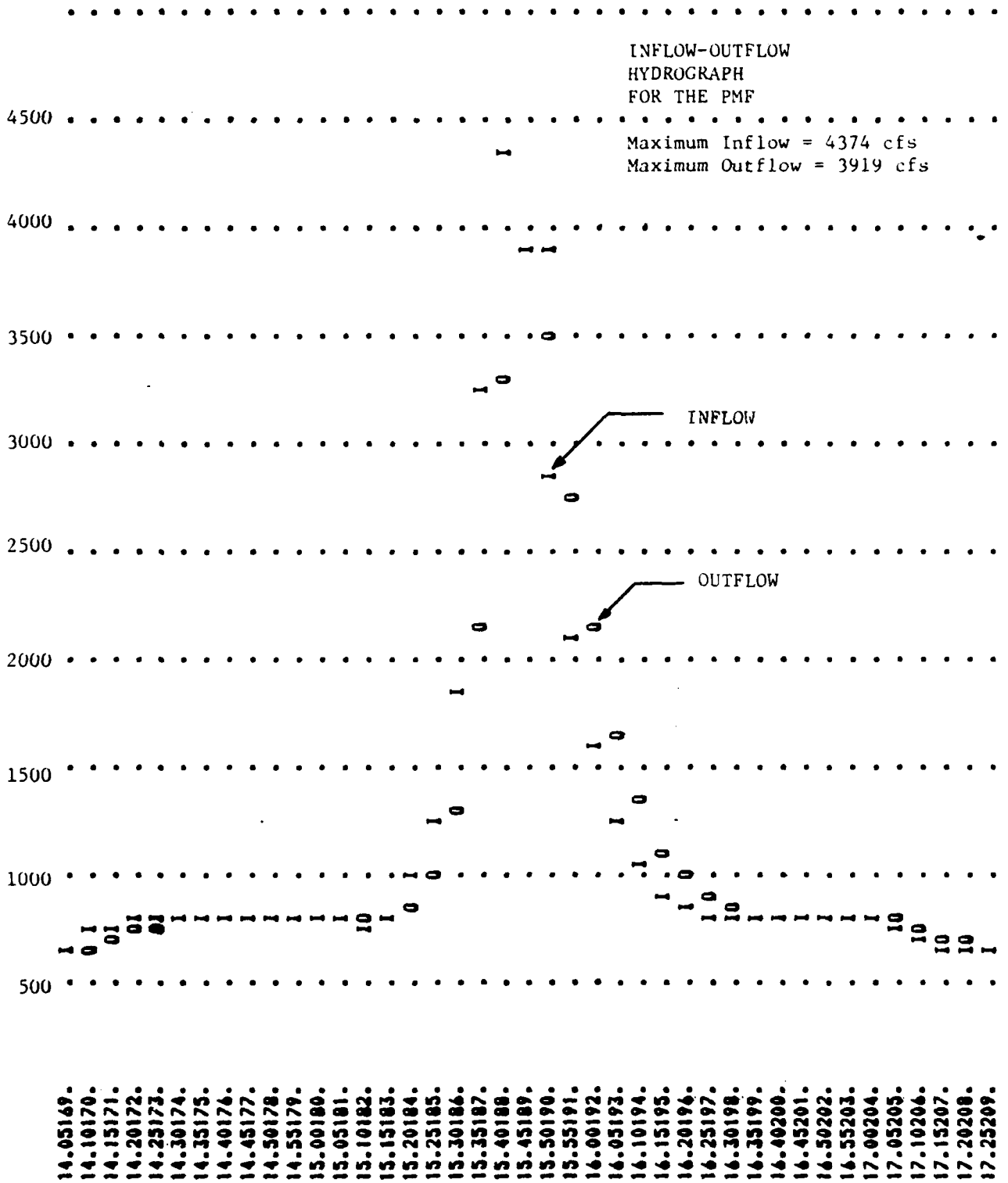
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS						
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7
				0.10	0.15	0.20	0.25	0.40	0.50	1.00
HYDROGRAPH AT	1	0.33	1	437.	656.	875.	1094.	1750.	2187.	4374.
	(	0.85)	(	12.39)(	18.58)(	24.77)(	30.96)(	49.54)(	61.93)(	123.86)(
ROUTED TO	2	0.33	1	169.	274.	418.	604.	1348.	1855.	3919.
	(	0.85)	(	4.79)(	7.77)(	11.84)(	17.10)(	38.16)(	52.54)(	110.98)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	815.20	815.20	818.10
STORAGE	106.	106.	131.
OUTFLOW	0.	0.	280.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.10	817.30	0.00	124.	169.	0.00	16.00	0.00
0.15	818.06	0.00	131.	274.	0.00	16.00	0.00
0.20	818.59	0.49	136.	418.	0.75	15.92	0.00
0.25	818.98	0.88	141.	604.	1.08	15.92	0.00
0.40	819.65	1.55	148.	1348.	3.00	15.75	0.00
0.50	819.96	1.86	152.	1855.	4.33	15.75	0.00
1.00	820.95	2.85	165.	3919.	6.67	15.75	0.00



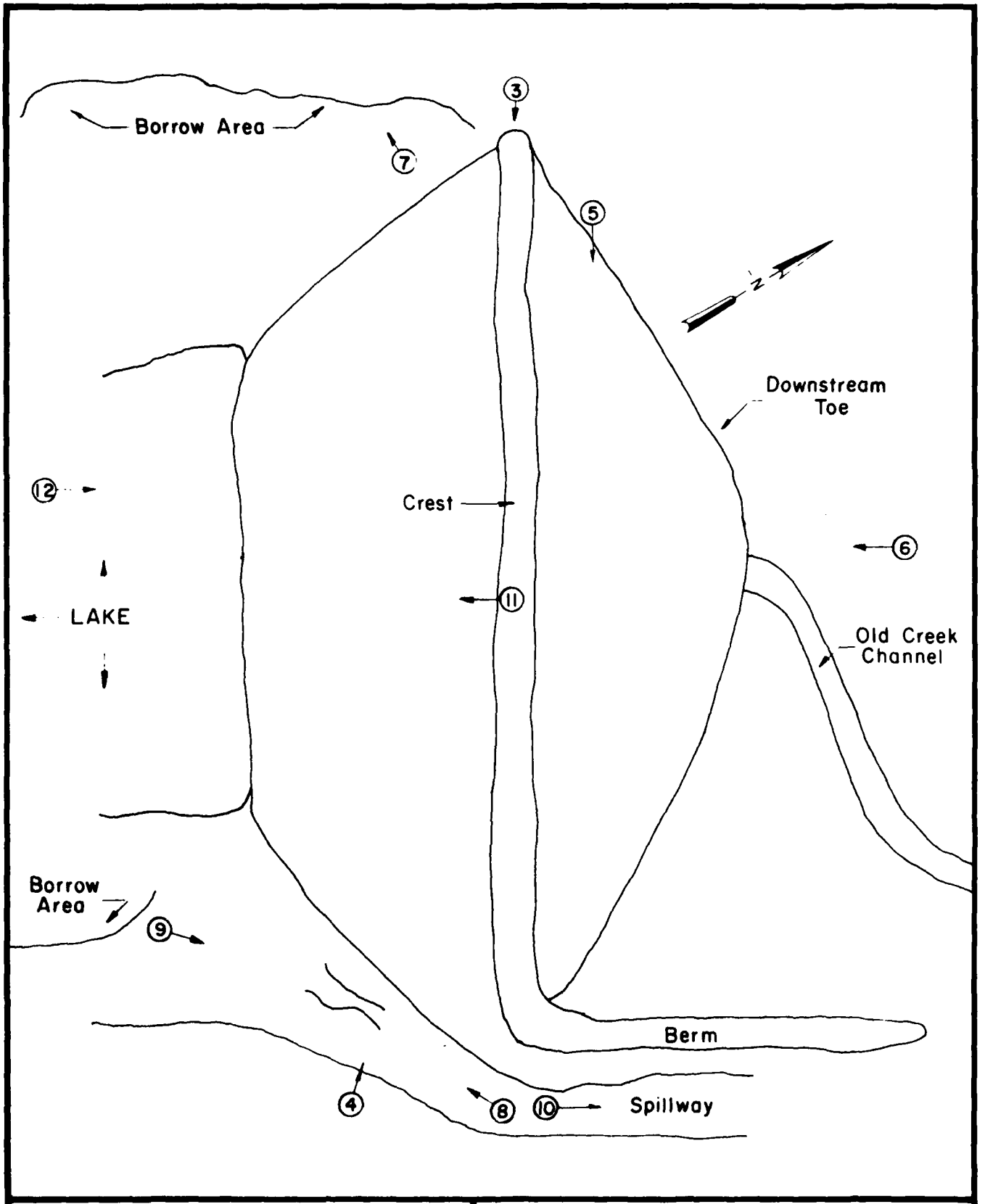
Sheet 9, Appendix C

APPENDIX D

Photographs

LIST OF PHOTOGRAPHS

Photo No.	
1	Aerial View of Lake and Dam Looking Northwest
2	Aerial View of Lake and Dam Looking South - Note Trailer Downstream
3	Crest of Dam Looking Southeast From Left Abutment
4	Upstream Face of Dam Looking Northwest From Right Abutment
5	Downstream Face of Dam Looking Southeast From Left Abutment Area
6	Downstream Face of Dam Looking South From Downstream Valley Area
7	Borrow Area at Left Abutment
8	Spillway Looking Upstream From Crest
9	Spillway Looking Up At Crest Area From Edge of Lake
10	Spillway Looking Downstream From Crest
11	Lake Looking Upstream From Top of Dam
12	Lake and Dam Looking North From Upper Edge of Lake



Photograph Locations

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

J. Bristow Lake Dam
Crawford County, Missouri
Mo. I.D. No 30985

Sheet 2, Appendix D


1


2

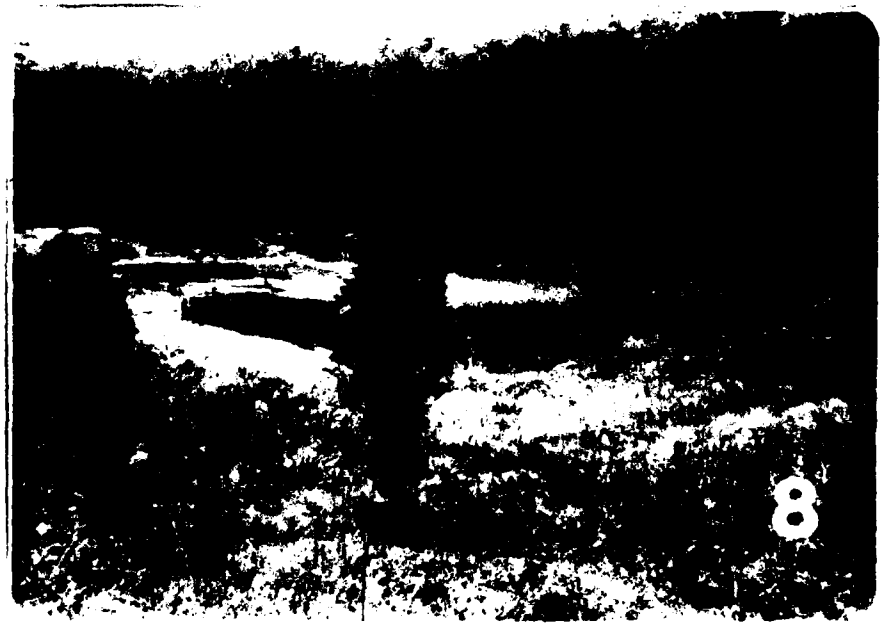

3


4


5


6


7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11


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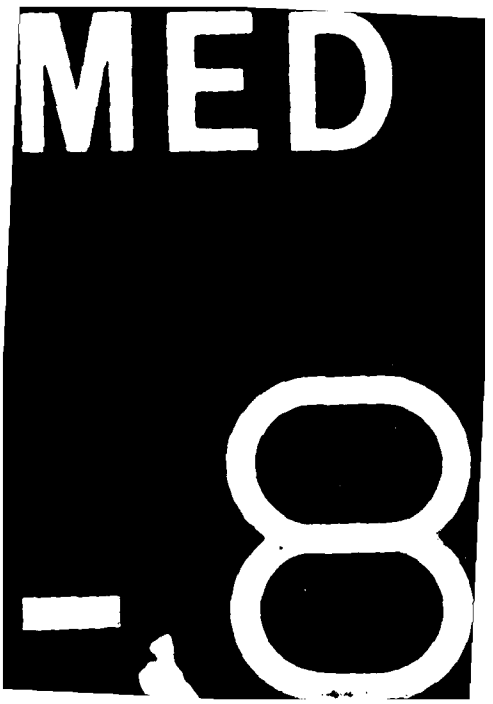
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